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Title: From Majorana to LEGEND - live from the Davis

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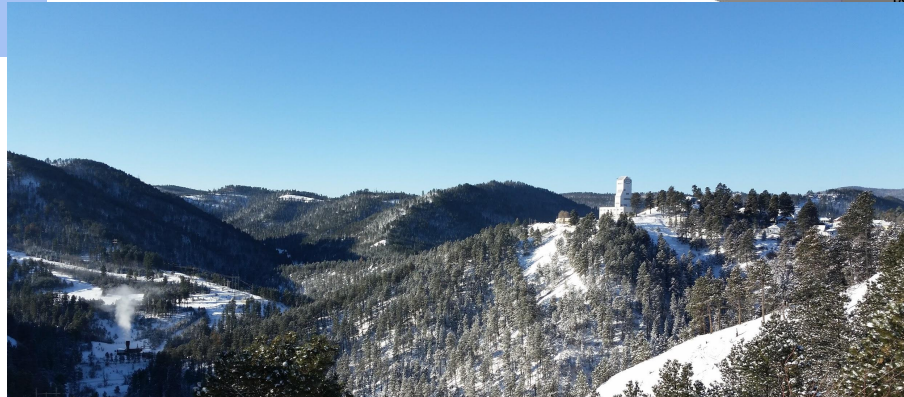
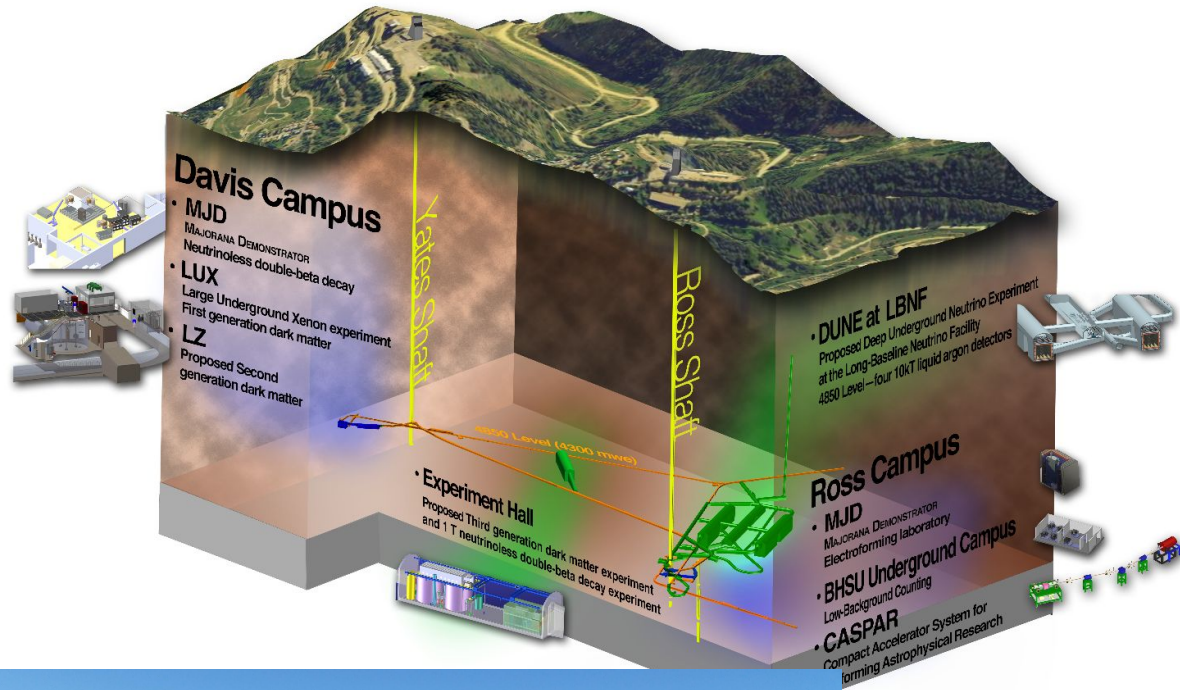
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# From MAJORANA To LEGEND

Ralph & Sam  
P-1



From the  
Davis Campus



# A short physics summary on double beta-decays

- 2<sup>nd</sup> order weak process
- Observable when single  $\beta$ -decay not possible
- With and without neutrino emission
- $0\nu\beta\beta$  requires the neutrino to be its own antiparticle
- ❖ Physics beyond the standard model needed
- ❖ Non-zero mass neutrinos
- ❖ A path into Leptogenesis



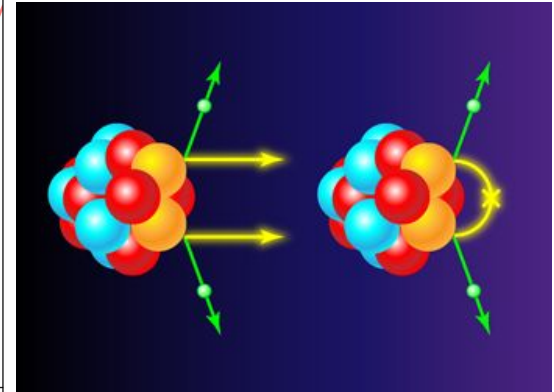
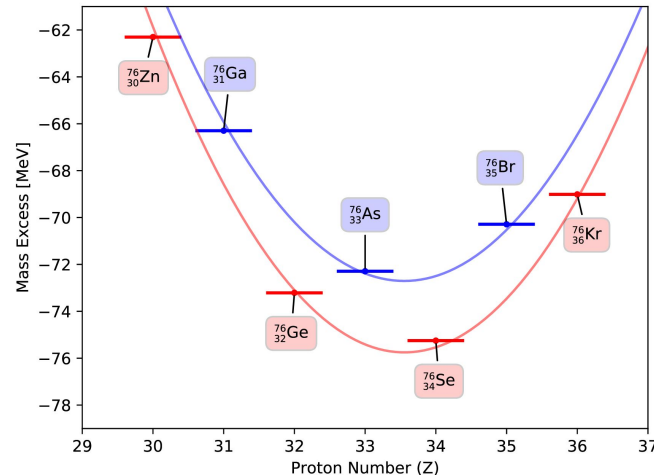
Maria Goeppert Mayer 1935 calculated the rate of 2-neutrino double-beta decay: Phys. Rev. 48, 512 (1935).



Ettore Majorana built a theory of neutrinos that are their own antiparticles; Nuovo Cimento, 14, 171 (1937)

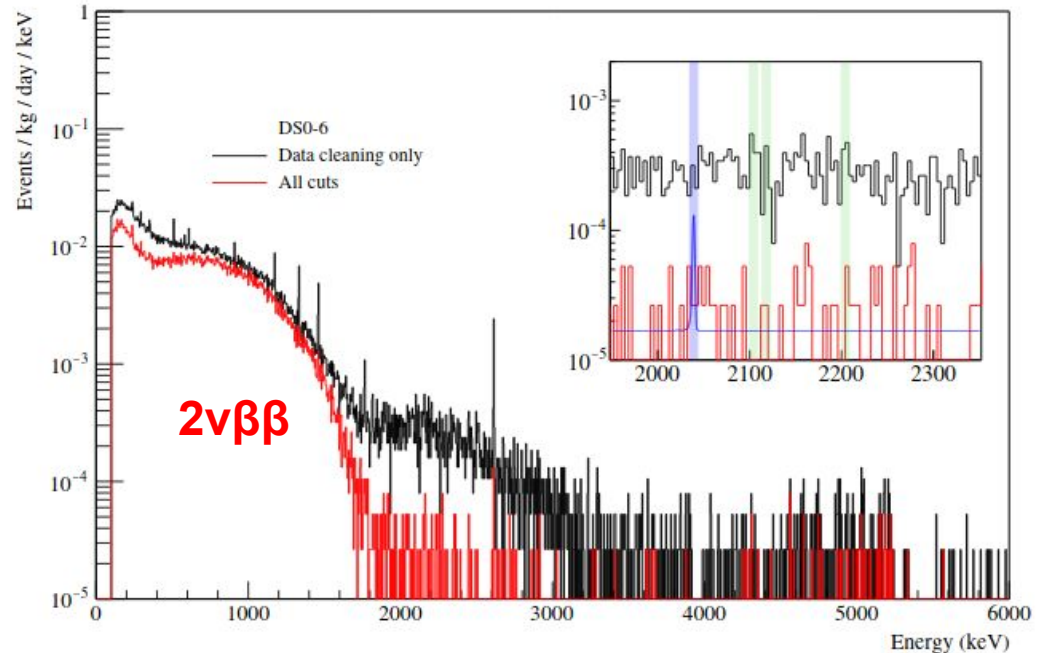


Wendell Furry 1939, discussed the possibility of neutrino-less double-beta decay as a test of the theory of Ettore Majorana, Phys. Rev. 56 (1939) 1184-1193..



# From an experimentalist point of view

- Extremely rare process
  - $T_{1/2} > 10^{26}$  years ( $0\nu\beta\beta$ )
  - Rate for this limit :  
~1 cts/(ton yr) @ 2 MeV
- Search for signal at the Q-value
- Use germanium detectors enriched in  $^{76}\text{Ge}$  (~88%)
- Key points for a successful experiment are:
  - Energy resolution
  - Background reduction
  - Exposure (Mass \* Time)
  - Efficiency



Phys. Rev. Lett. 120, 132502

Phys. Rev. C 100, 025501

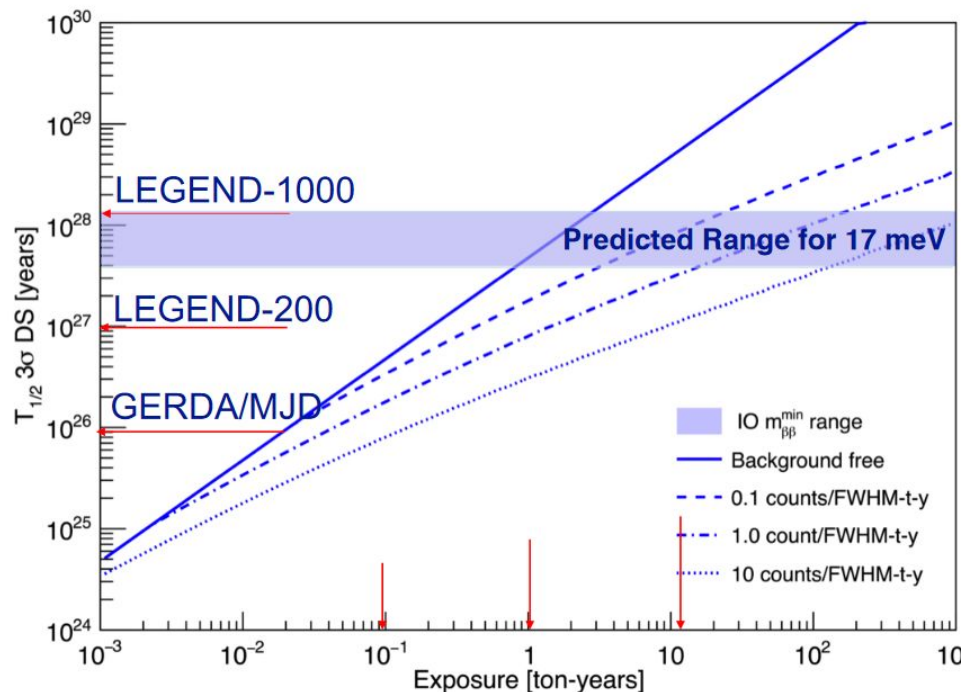


# From MAJORANA to LEGEND



Large Enriched  
Germanium Experiment  
for Neutrinoless  $\beta\beta$  Decay

- Current generation experiments in using germanium achieved the world leading results in **resolution and background**
- Best Limit set with modest exposures
- Next generation combines the best of GERDA and MAJORANA
- LEGEND-200 starts data taking this year
- LEGEND-1000 competes in DOE portfolio review this summer



$$\left[ T_{1/2}^{0\nu} (0^+ \rightarrow 0^+) \right]^{-1} = G^{0\nu}(E_0, Z) |M^{0\nu}|^2 \langle m_{\nu_e} \rangle^2$$



# LANL's role

- Leadership roles in MAJORANA and LEGEND
  - Spokesperson, Executive committee chairs (MJD)
  - Task leads for lab infrastructure, calibration, detector work, data cleaning, and high-energy physics
- Past LANL investments (LDRD) have driven:
  - Development of the point-contact germanium detector supplies from different vendors
  - Develop a 2<sup>nd</sup> isotope vendor to reduce risk and price
  - Crucial contributions in nuclear matrix elements and particle theory
- Our plan forward
  - Lead the Post MAJORANA Physics effort:  
**Measure the decay of  $^{180\text{m}}\text{Ta}$**
  - Play a crucial role in the heart of LEGEND:  
**Drive the R&D efforts in the development  
Of large scale Point Contact detectors**



From our pre-Covid planning retreat